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AUTOMATION OF TRAINING METHODS AND JUDGING OF AEROBATIC FLIGHTS

Anita Linka, Agnieszka Wróblewska

Poznan University of Technology, Chair of Thermal Engineering
Piotrowo Street 3, 60-965 Poznan, Poland
tel.: +48 506 048 036, +48 61 6552213
e-mail: anita.d.linka@doctorate.put.poznan.pl
agnieszka.wroblewska@put.poznan.pl

Abstract

The article presents the specificity of aerobatic operations that use on-board transmitters to improve the quality of training and judging in this sport area. The first chapter of this work is an introduction to the topic under discussion and the second chapter describes the principles of aerobatic competitions, methods of judge evaluations and the regulations related to the correctness of the figure performance by the pilots. The third chapter contains information on the AeroSafetyShow Demonstrator+PL system (ASSD+PL) used to carry out active supervision over flights in general aviation (especially in gliders and airplanes aerobatic). In the fourth chapter of the article, the possibilities of application of the ASSD+PL system functionalities were described which could improve the quality of training and judge evaluations. The Polish measurement system is actually an only electronic system, which is accepted and respected by the aerobatic judges all over the Europe. Functionalities of the ASSD+PL are used by them to control and sum up all the forbidden crosses the box. The pilot flying too low can be even disqualified. Application interface can be also transmitted in the real time to the big screen as well for the judges, as for the wide spectators watching the competitions flights.

Keywords: *aerobatics, aerobatic training, aerobatic judging, on-board transmitters, supervision system*

1. Introduction

Today we are observing an increasing tendency for automation in new fields of life. The technology not only allows more accurate task performance but also improves the reliability and optimization of various processes. A dictionary defines automation as the application of devices to collect and process information, taking over certain cognitive, intellectual and decision-making activities of humans (thus far performed solely by them) while using objects such as machines, aircraft, banks or while performing creative works such as design, construction or learning [1]. According to the above definition, new technologies are increasingly used in all fields of life. A similar trend can be observed in sports. The example may be basketball games (video replays) or tennis (the system of cameras referred to as the Hawkeye visually tracking the trajectory of the ball and its position as it touches the ground) [2]. Automation mainly contributes to the improvement of the competitors' skills (trainings). Devices monitoring daily activities of a sportsman or training analysis smart phone applications have also become commonplace. They not only provide real time information but also allow an analysis after completion of an activity. Thanks to such technologies, it is possible to improve one's own skills in a continuous way.

Flight aerobatics with its specificity is much different from other sports disciplines. Great speeds and the lack of systems allowing proper evaluation of the flight are a challenge for the competitors, the coaches and the judges. The application of on-board transmitters sending signals in real time may turn out to be of key importance for the improvement of the level of training within the discussed discipline [11].

In this article, the authors will determine the possibilities and applicability of the ASSD+PL transmitters in the training process and aerobatics.

2. Basics related to flight aerobatics

The competitions in flight aerobatics fall into two categories: Advanced (higher) and Unlimited (professional competitive) differing in the level of difficulty of the prepared sequence of aerobatic figures. All figures are performed in a limited space of the size of 1000x1000x1000 m (*the box*). The judge stands are located 150-250 m from the boundary of the box. From this perspective, the judges evaluate the flights for correctness of the figures, maintenance of position in the box and harmony of the flight. All figures that the competitor is allowed to perform are included in the *ARESTI* catalogue. It contains a collection of 2-dimensional evolutions grouped into 9 families (similar in terms of flight geometry e.g. barrel, tailslides) (Fig. 1) [5].

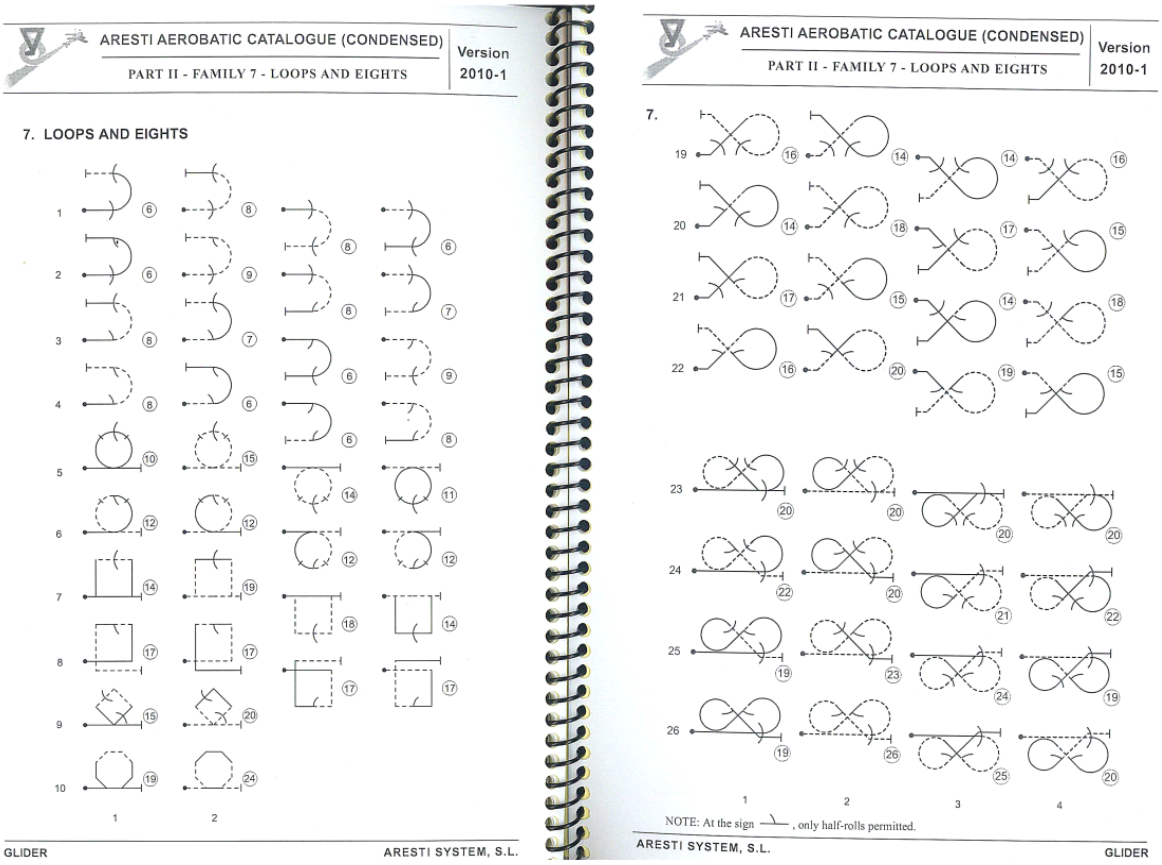


Fig. 1. ARESTI figures [6]

Additionally, the judges negatively evaluate each transgression of the zone boundary. A serious transgression of the bottom limit may even lead to disqualification.

Currently, there are three different programs in the competition:

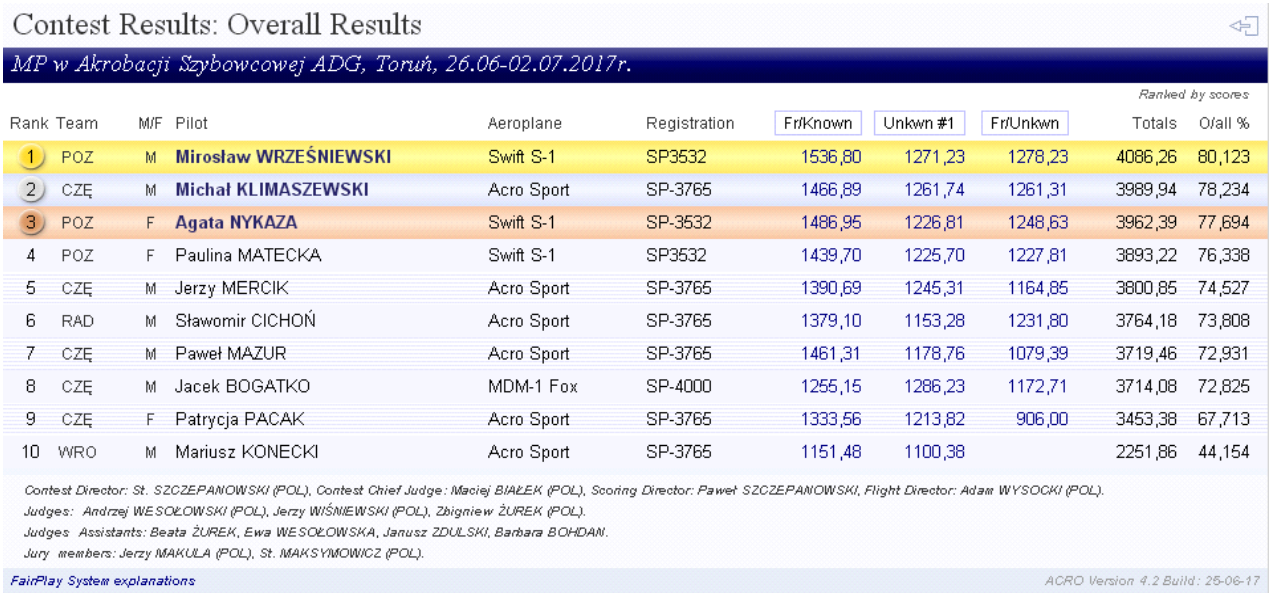
- Free Known – prepared and submitted by each competitor,
- Free Unknown,
- Unknown.

The description of individual programs has been shown in Tab. 1.

The competitions are deemed valid if at least 3 aerobatic programs are played with a maximum of six (free known, free unknown and unknown). The scores given by the judges for the competition flights are entered in the dedicated *Aerobatic Contest Result Organizer (ACRO).* The example table with the results are presented in Fig. 2. The judge scores are converted by the software according to the *Fair Play System* (FPS) that, through statistical operations, determines the final order of the competitors in the table. The application of both the ACRO software and the FPS method aims at avoiding situations of unfair or wrong evaluation of the flights [3].

Tab. 1. Glider aerobatic programs [3]

	Free Known (program 1)	Free Unknown (program 3)	Unknown (program 2, 4, 5, 6)
Number of figures	10	8-9	7-10
Figures included in:	ARESTI CATALOGUE	Sporting Code, Section 6, Part 2 APPENDIX A (ARESTI)	Sporting Code, Section 6, Part 2 APPENDIX A (ARESTI)
Composition of the program	The program is composed of 10 figures: - 5 are selected at an annual CIVA conference, - another 5 are chosen by the competitor according to the *Sporting Code*, - the competitor is free to prepare a competition program from chosen figures.	The competitor sends his program to the jury prepared in the following manner: - not later than 24 hours before program submission deadline the judges publish 7 figures that were selected from schedule A to the *Sporting Code*, - the competitor composes a program from the 7 obligatory figures and 1 or 2 additional transitional figures, - the program must be sent to the judges no later than 24 hours before the competition begins.	The sum of all figures in programs 2, 4, 5, 6 is 35; they are chosen from schedule A to the *Sporting Code*; figures are submitted by a delegation of two competitors who draw lots; Then the judges determine further programs; If a figure was already performed it cannot be repeated; the jury chooses one of the submitted sequences that is published for the competitors not later than 12 hours before the start of a given competition.
Training allowed	YES	NO	NO



Contest Results: Overall Results

MP w Akrobacji Szybowcowej ADG, Toruń, 26.06-02.07.2017r.

Ranked by scores

Rank	Team	M/F	Pilot	Aeroplane	Registration	Fr/Known	Unkwn #1	Fr/Unkwn	Totals	O/all %
1	POZ	M	**Mirosław WRZEŚNIEWSKI**	Swift S-1	SP3532	1536,80	1271,23	1278,23	4086,26	80,123
2	CZĘ	M	**Michał KLIMASZEWSKI**	Acro Sport	SP-3765	1466,89	1261,74	1261,31	3989,94	78,234
3	POZ	F	**Agata NYKAZA**	Swift S-1	SP-3532	1486,95	1226,81	1248,63	3962,39	77,694
4	POZ	F	Paulina MATECKA	Swift S-1	SP3532	1439,70	1225,70	1227,81	3893,22	76,338
5	CZĘ	M	Jerzy MERCIK	Acro Sport	SP-3765	1390,69	1245,31	1164,85	3800,85	74,527
6	RAD	M	Sławomir CICHOŃ	Acro Sport	SP-3765	1379,10	1153,28	1231,80	3764,18	73,808
7	CZĘ	M	Paweł MAZUR	Acro Sport	SP-3765	1461,31	1178,76	1079,39	3719,46	72,931
8	CZĘ	M	Jacek BOGATKO	MDM-1 Fox	SP-4000	1255,15	1286,23	1172,71	3714,08	72,825
9	CZĘ	F	Patrycja PACAK	Acro Sport	SP-3765	1333,56	1213,82	906,00	3453,38	67,713
10	WRO	M	Mariusz KONECKI	Acro Sport	SP-3765	1151,48	1100,38		2251,86	44,154

Contest Director: St. SZCZEPANOWSKI (POL), Contest Chief Judge: Maciej BIAŁEK (POL), Scoring Director: Paweł SZCZEPANOWSKI, Flight Director: Adam WYSOCKI (POL).
Judges: Andrzej WESOŁOWSKI (POL), Jerzy WIŚNIEWSKI (POL), Zbigniew ŻUREK (POL).
Judges Assistants: Beata ŻUREK, Ewa WESOŁOWSKA, Janusz ZDULSKI, Barbara BOHDAN.
Jury members: Jerzy MAKUŁA (POL), St. MAKSYMOWICZ (POL).

FairPlay System explanations ACRO Version 4.2 Build: 25-06-17

Fig. 2. Competition table created by the ARESTI software [7]

Unfortunately, there are still cases when competitors contest the results generated by the software. There have been several cases of complaints related to the system operation. In order to investigate the FPS rules and the operation of the ACRO software, in 2016 works were initiated at Poznan University of Technology to develop autonomous evaluation software. The idea behind it is to confirm or reject the thesis related to the errors occurring at the stage of point calculation

(negative points in particular, given for transgression of the aerobatic zone) that changes the results of individual competitors. The development of an independent system aims at improving the currently applied evaluation tools in flight aerobatics.

3. AeroSafetyShow+PL

Another tool serving the purpose of improving the quality and reliability of aerobatic evaluations is the AeroSafetyShow Demonstrator+PL (ASSD+PL) developed and financed by the European Union. ASSD+PL is an intelligent real-time flight operations supervision and safety system dedicated to General Aviation. A wide scope of functionalities ensures a comprehensive analysis during the flight and after its completion. The system is the only judge-assisting tool used in international championships (glider aerobatics in particular).

In the three years of the project duration, the pilots of Aerobatic Group Żelazny and the team associated with Poznan University of Technology developed comprehensive software that sends information related to the flight parameters to the flight controller in real time. The data is visualized on the screens of the base station, which allows a direct intervention of the operator in the flight.

The data is sent via radio waves through the transmitters (portable modules, Fig. 3), fitted inside the aircraft. The modules are fitted with dedicated, universal mounting bracket. The signal is transmitted to the receiving station linked to the PC with the ASSD+PL application installed allowing a reproduction of the flight in a 3-dimensional space in real time. The main functioning components of the modules are a processor, radio RF modules, an RF antenna, a GPS receiver, GPS antennas, a slot with a microSD card, a buzzer, and a LiPo battery with a charging system [8, 9]. Within the project, the (UUM) fixing holders were designed and made based on velcro pads and mushroom velcros (Fig. 3) [8].

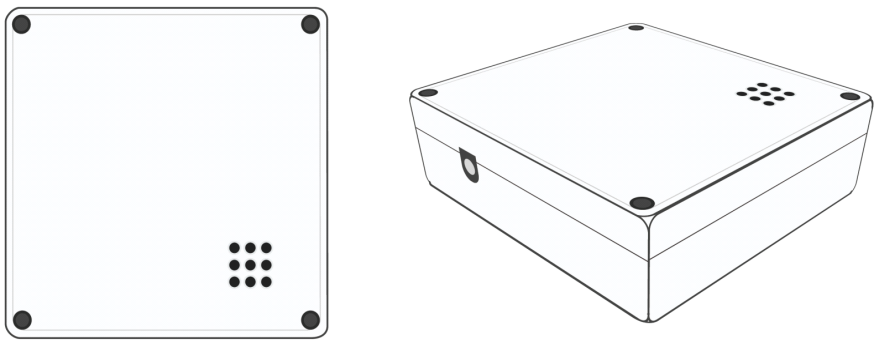


Fig. 3. ASSD+PL portable module

The scientific consortium claimed a patent for the mounting system (4 configurations of the holder with adapters). Holders are made from nylon formed by 3D printing, which guarantees proper strength and does not influence the operation of the transmitters.

In order to ensure optimum operation of the system, the base station was built on a passenger vehicle (Mobile Controller). The vehicle was divided into two compartments – the operator's compartment and the technical compartment. The first compartment is designed for the ground controllers and is fitted with screens, standalone Wifi, air conditioning and UPS. The second one includes the equipment such as the power generator, 8-meter pneumatic mast with a receiver and a RACK with the servers. The vehicle is fitted with warning lights and buzzers. Owing to all the functionalities of the Mobile Controller, it is possible to carry out the supervision process at any location, irrespective of the terrain and weather conditions [8, 9].

The ASSD+PL system allows visual supervision in three forms:

- 360º camera,

- directional camera – controlled through a panel by the operator, night vision included (infrared),
- multifocal tracking cameras – automatic tracking of an aircraft fitted with a portable module (patent claimed by Poznan University of Technology).

The ASSD+PL system is used to provide safety during many domestic and international competitions. Its functionalities assist judges in their evaluations (particularly maintaining of the position in the aerobatic zone). Each time after the flight is completed, a report is printed including the times and positions of the zone transgression and then passed to the judges giving penalties to the pilots on that basis. The system also enables a reproduction of the flight and its analysis if necessary. Additionally, the system can provide real time broadcast to the spectators.

4. Using the functionalities of the ASSD+PL system in the training and evaluation of aerobatic flight

The training process and the process of aerobatic flight evaluation are mainly based on visual reception of instructors and judges. A partial automation would eliminate mistakes resulting from the imperfection of the human senses. Aerobatic training would be more accurate and the real-time supervision would contribute to the level of safety of air operations. The analysis of trajectory in the form of a graphical model may be an additional component of the pilot training process [10] and serve to evaluate any deviations from correct competition flight trajectories. The interpretation of the recorded flight parameters may not only help evaluate the correctness of the aerobatic figures but also identify the pilot's mistakes influencing the flight safety [10].

In order to improve the quality of the pilot training, the functionalities related to the analysis of the flight trajectory may be used in the first place i.e. the possibility of switching views between '3D', 'horizontal plane' (position in the box) and 'altitude curve' (Fig. 4). An important feature is the real-time visualization of the flight parameters on the screen of the base station, which allows the instructor to respond immediately.

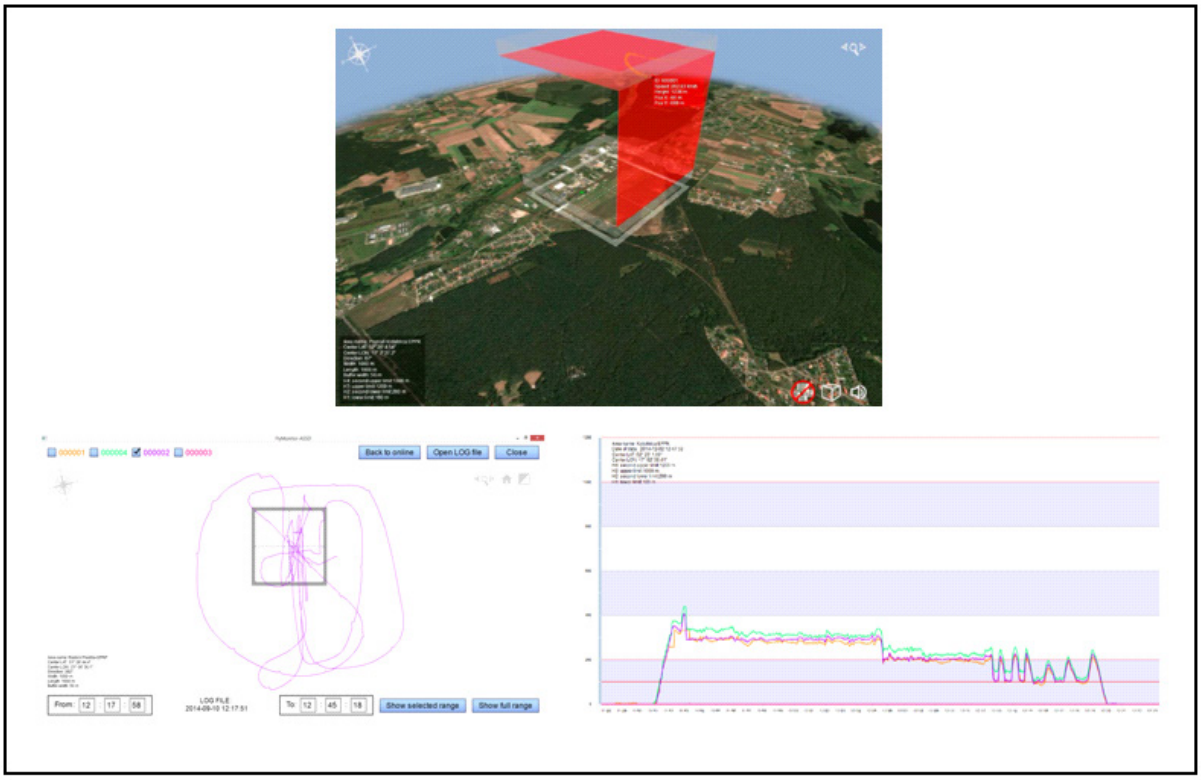


Fig. 4. Different viewing options within the ASSD+PL application

All data recorded by the modules are automatically stored by the base station and on the memory card fitted in the device. This allows retrieving any aerobatic flight (comparison purposes) but also the flight trajectory that was performed out of the reach of the systems. Such an option allows supervising the trainee pilot at all stages of the training.

Additionally, the software was equipped with a series of functionalities helping judge evaluations. The judge evaluation assistance can be carried out as follows:

- the 'Watch aerobatic' function serves to determine the start and the end of the competition flight; from the moment of the function activation, all air operations of the selected aircraft are included in the evaluation process in terms of position maintenance and out-of-the-box time calculation (Fig. 5),
- automatic printout of the reports after the flight has completed,
- visual determination of the boundaries of the aerobatic zone – transgression illuminated red and a buzzing sound,
- possibility of tracing up to 50 modules at a time – supervision of the position of consecutive competitors,
- recording of radio communications,
- video recording.

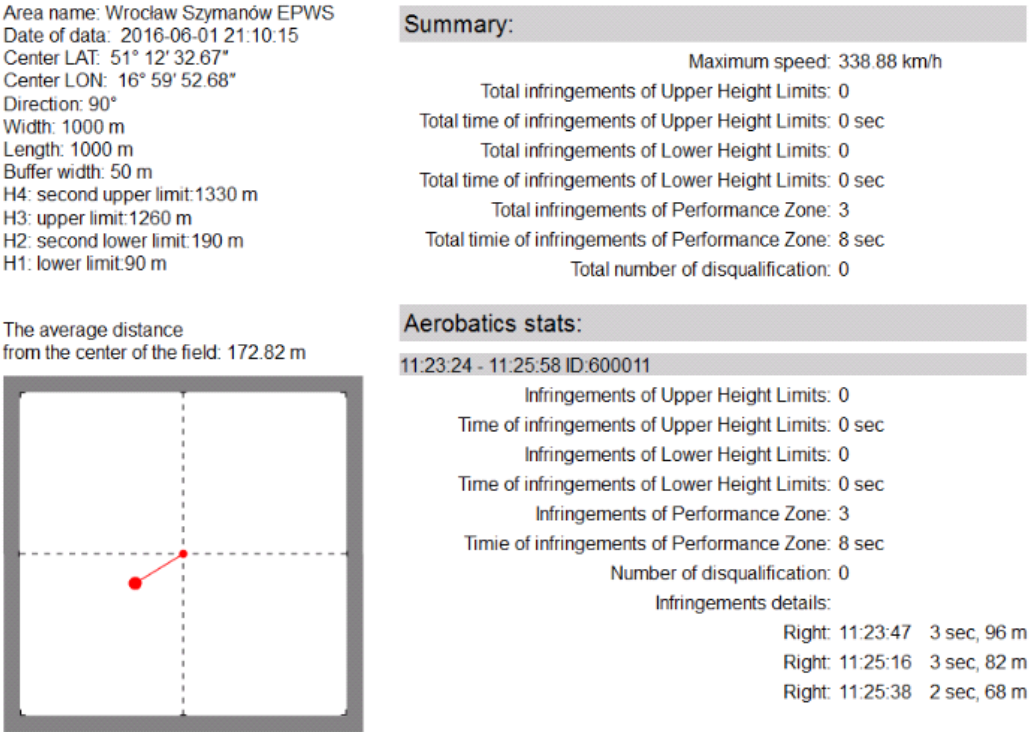


Fig. 5. Judge report in ASSD+PL

The ASSD+PL system has been designed to improve the art of piloting. Continuous supervision over the fulfilment of the air task and the function of judge assistance enables automation of part of the actions influencing accurate flight interpretation.

5. Conclusions

Recording of the basic flight parameters of an aircraft and the possibility of their analysis is an important question in pilot training and judge evaluation of aerobatic flights [8, 10, 11]. The application of on-board transmitters may also increase safety of the flight operations. The use of the functionalities of ASSD+PL helps not only eliminate the judge evaluation mistakes but also

allows recording of the flights along with their basic parameters. The software proposed by the ASSD+PL team is a comprehensive solution for general aviation primarily in terms of safety of the air shows, competitions and aerobatic practice. An intelligent and autonomous system will allow a gradual reduction of the risk of occurrence of hazardous events at a simultaneous improvement of the precision and quality of performance of the aerobatic figures.

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